



University of Chester



**This work has been submitted to ChesterRep – the University of Chester's
online research repository**

<http://chesterrep.openrepository.com>

Author(s): Joshua Roy Stroud

Title: Nutrition knowledge and food intake

Date: September 2013

Originally published as: University of Chester MSc dissertation

Example citation: Stroud, J. R. (2013). *Nutrition knowledge and food intake*.
(Unpublished master's thesis). University of Chester, United Kingdom.

Version of item: Submitted version

Available at: <http://hdl.handle.net/10034/313314>



Department of Clinical Sciences and Nutrition
MSc Exercise and Nutrition Science

Module Title: Research Project
Module Code: XN7523
September 2013

Nutrition knowledge and food intake

Assessment NumberF00131.....
Word count: Review Paper5240.....
Word count: Research article4630.....

Contents

1. Literature review - Nutrition knowledge and food intake.....	p. 4
1.1. Abstract.....	p. 4
1.2. Introduction.....	p. 5
1.3. Rates of chronic NCDs in the UK.....	p.6
1.4. Relationship between NCDs and diet.....	p.10
1.5. Factors Affecting Food Intake.....	p. 12
1.6. Research into relationship between nutrition knowledge and food intake.....	p. 13
1.6.1. <i>Summary table of previous research.....</i>	Appendix 1, p. i
1.6.2. <i>Historical Studies.....</i>	p. 14
1.6.3. <i>Intervention studies with child participants.....</i>	p. 15
1.6.4. <i>Intervention studies with adult participants.....</i>	p. 19
1.6.5. <i>Cross-sectional studies.....</i>	p. 20
1.7. Confounding factors: attempting to isolate the effect of nutrition knowledge.....	p. 26
1.8. Conclusion.....	p. 27
2. Research project - Is nutrition knowledge related to food intake in free- living adults?.....	p. 30
2.1. Appropriate journal.....	p. 31
2.2. Abstract.....	p. 31
2.3. Introduction.....	p. 32
2.4. Methods.....	p. 33
2.4.1. <i>Study design.....</i>	p. 33
2.4.2. <i>Participants.....</i>	p. 33
2.4.3. <i>Nutritional knowledge assessment.....</i>	p. 34
2.4.4. <i>Dietary assessment.....</i>	p. 35
2.4.5. <i>Experimental procedure.....</i>	p. 35
2.4.6. <i>Data analysis.....</i>	p. 36
2.5. Results.....	p. 38
2.6. Discussion.....	p. 41

2.6.1. <i>Main findings</i>	p. 42
2.6.2. <i>Main findings in relation to previous research</i>	p. 43
2.6.3. <i>Null findings in relation to previous research</i>	p. 44
2.6.4. <i>Limitations and Flaws</i>	p. 46
2.6.5. <i>Confounding factors</i>	p. 50
2.6.6. <i>Clinical relevance of results</i>	p. 51
2.7. Conclusion.....	p. 53
Reference list.....	p. 55

Appendix 1. Summary table of previous research

Appendix 2. Nutrition knowledge questionnaire

Appendix 3. Participant guide

Appendix 4. Participant Information Sheet

Appendix 5. Informed consent form

Appendix 6. Screening questionnaire

Appendix 7. Recruitment advertisement

Due to time constraints, the planned method implicated in Appendices 3,4, and 5 was eventually altered

1. Literature review

1.1. Abstract

The rates of many diet related diseases are increasing; obesity most notably. Adverse shifts in dietary behaviours have contributed to the rise in non-communicable diseases. In the UK fat and sugar intakes are above recommended levels and fruit, vegetable and oily fish intakes are below recommended levels. Increasing nutrition knowledge may be a means of bringing intake in-line with the recommendations. It was the aim of this review to assess the evidence for and against a relationship between nutrition knowledge and food intake. Intervention studies suggest that improving nutrition knowledge correlates with improvements in food intake. However, cross-sectional evidence of a correlation is much less clear although a low correlation does appear to exist. A mediatory effect of nutrition knowledge on the influence of demographic variables may also exist. Further research into the correlation with regard to specific nutrients and demographic variables is required. As is exploration of the long-term benefits of nutrition education interventions.

1.2. Introduction

“Diet has been known for many years to play a key role as a risk factor for chronic diseases” (WHO, 2003, p. 6).

Data from the World Health Organisation [WHO] (2013) states that of 57 million global deaths in 2008, 36 million, or 63%, were due to non-communicable diseases (NCDs). The leading causes of deaths from NCDs in 2008 were cardiovascular diseases (17 million deaths, or 48% of all NCD deaths) and cancers (7.6 million, or 21% of all NCD deaths) with diabetes causing 1.3 million, or 4% of all NCD deaths.

Chronic NCDs

create large adverse - and underappreciated - economic effects on families, communities and countries. In 2005 alone, it is estimated that the United Kingdom will lose 2 billion dollars in national income from premature deaths due to heart disease, stroke and diabetes. (WHO, 2005, p. 2)

The WHO (2003) suggests that cardiovascular diseases, diabetes and cancers present the greatest public health burden with obesity, osteoporosis and dental diseases making significant contributions.

1.3. Rates of chronic NCDs in the UK

In the UK, the incidence and prevalence of diabetes, cancer, obesity and osteoporosis are on an upward trend. A report by Diabetes UK (2010) suggests that the number of people diagnosed with diabetes has increased from 1.4million in 1996 to 2.6 million in 2010. By 2025, it is estimated that five million people will have diabetes in the UK.

Data published by Cancer Research UK (2012) states that the current incidence rate for all cancers (excluding non-melanoma skin cancer) is approximately 394 cases for every 100000 people. The European age-standardised incidence rates in Great Britain increased by 22% in males during the period 1975-1977 to 2008-2010 and by 42% in females as demonstrated in Figure 1.

Figure 1. European age-standardised incidence rates for all cancers excluding non-melanoma skin cancer in Great Britain, 1975-2010 (Cancer Research UK, 2012).

A pertinent example of trends in cancer rates is kidney cancer which counts obesity as an established risk factor. Kidney cancer increased by 26% in men and 35% in women between 2001 and 2010 (Cancer Research UK, 2012).

Recent analysis of the Health Surveys for England suggests that weight trends are following an unhealthy pattern - median BMI increased for men from 25.6 kg/m² in 1992 to 27.5 kg/m² in 2010. For women median BMI increased from 24.5 kg/m² in 1992 to 26.5 kg/m² in 2010 (Sperrin, Marshall, Higgins, Buchan & Renehan, 2013).

Of greater concern is the prevalence of obesity which is a risk factor for a host of NCDs. In the UK as a whole, past trends predict that by 2030 the prevalence of obesity will rise from 26% to 41-48% in men, and from 26% to 35-43% in women. This would equate to 11 million more obese adults by 2030 (Wang, McPherson, Marsh, Gortmaker & Brown, 2011)

The incidence of osteoporosis is also predicted to increase. Data shows that since 1968 incidence has shown an overall increase and based on current trends, hip fracture rates may increase from 46,000 in 1985 to 117,000 in 2016 (Dennison, Cole & Cooper 2005). Hip fractures cause the most morbidity and greater risk of dying may persist for at least 5 years afterwards.

However, other prominent diseases highlighted as a cause for concern by the WHO buck the upward trend: data from the Adult Dental Health Survey of

England, Wales and Northern Ireland in 2009 (Steele & O'Sullivan, 2011) suggests that dental diseases are becoming less prevalent. Figure 2 demonstrates that the percentage of English adults with dental caries was considerably lower in 2009 than it was in 1998. In addition, the percentage of English adults with periodontal disease fell from 55% in 1998 to 45% in 2009.

Figure 2. Trends in percentage of dentate adults with dental caries (decay), England 1998 and 2009 (Steele & O'Sullivan, 2011)

In Northern Ireland the percentage of adults with periodontal disease also fell from 48% in 1998 to 38% in 2009, whereas Wales saw a slight increase in the disease from 47% in 1998 to 50% in 2009.

Although these trends for dental health are encouraging, attention to risk factors for dental disease is still important; there are many possible reasons for the

improvement in dental health, such as improved dentistry and improved personal oral care.

Greater encouragement comes from data from the European Society of Cardiology (2012) which shows that the rate of hospital discharges from coronary heart disease (CHD) in the UK fell from 523 discharges per 100000 people in 2000 to 421 in 2009. This implies that fewer people suffered from CHD in 2009 than in 2000. This is corroborated by a report by the British Heart Foundation (2011) which suggests that “the incidence of cardiovascular conditions in the UK has been decreasing since the 1960s, and is still continuing to decrease.” Furthermore, Lee, Shafe and Cowie (2011) demonstrated that stroke incidence in the UK has decreased and survival after stroke has improved in the past 10 years. Over this period, stroke incidence fell by 30%, from 1.48/1000 person-years in 1999 to 1.04/1000 person-years in 2008 as shown in Figure 3.

Figure 3. Diabetes incidence rate in the UK between 1999 and 2008 (Lee, Shafe & Cowie, 2011).

Despite these positive trends, NCDs are a major cause of premature deaths in the UK and the rising incidence rates require attention. It is possible that the increase in some chronic NCDs is due to recent improvements in detection and greater awareness of disease. In addition, the age of the UK population is increasing which perhaps increases the incidence of disease and will almost certainly increase disease prevalence as treatment has improved in recent years and continues to improve. However, the contribution of errant lifestyle factors to the incidence of NCDs must be considered.

1.4. Relationship between NCDs and diet

Physical activity, smoking, alcohol consumption and diet will all play a part in the development of disease: the WHO (2003) suggests that the aforementioned NCDs -cardiovascular diseases, diabetes, cancers, obesity, osteoporosis and dental diseases - can all be related to diet and nutrition. Globally, adverse dietary changes are occurring including shifts in the structure of the diet towards a higher energy density diet with a greater saturated fat intake (mostly from animal sources), reduced intakes of complex carbohydrates and dietary fibre, and reduced fruit and vegetable intakes (Popkin, 2006).

Adverse dietary changes have been observed in the UK: the UK National Diet and Nutrition Survey of 2008-2010 (2011) reflects the findings of previous surveys carried out in 1992 and 2001 in that intake of saturated fat and sugars in the UK remain above recommended levels. The survey of 2008-2010 also found that intakes of fruit, vegetables and oily fish were below the recommended levels.

Inappropriate intake of certain foods is related to certain diseases. With regard to the dietary inadequacies highlighted by the UK National Diet and Nutrition Survey of 2008-2010 (2011), evidence suggests related diseases. Adequate intake of fruit and vegetables and oily fish may reduce the risk of many types of cancer and bowel cancer respectively (Hall, Chavarro, Lee, Willet & Ma, 2008; Key, 2011). Whereas excess fat and sugar intake could contribute to coronary heart disease and type 2 diabetes (Howard & Wylie-Rosett, 2002).

However, there is evidence of positive dietary changes in the UK which perhaps explain the downward trend for cardiovascular disease. The apparent reduction in the incidence of cardiovascular disease in the UK may be due in part to changes in diet such as an increase in the intake of whole grains and an increase in the ratio of polyunsaturated fat intake to saturated fat intake (Webb, 2008). Figure 4 demonstrates the trend in fat intake and shows that in 2008 60 grams of vegetable oils per person per week were consumed compared to 40 grams of butter and 3 grams of lard.

Figure 4. Trends in consumption of fats in Great Britain, 1961 to 2008 (Scarborough, Wickramasinghe, Bhatnagar & Rayner, 2011).

Despite some positive dietary changes with associated health benefits, average UK intakes do not adhere to recommended intakes. In addition, increasing rates of obesity are a sign that UK diets require attention, especially as obesity is a risk factor for diseases such as type 2 diabetes, coronary heart disease and cancers. Therefore, the question is: how can diets be changed in order to prevent or delay the onset of disease? Firstly, the factors affecting food intake must be considered.

1.5. Factors affecting food intake

Food intake is a complex issue with varying influences. Webb (2008) suggests that “a host of seasonal, geographical, social and economic factors determine the availability of different foods to any individual group, whereas cultural and preference factors affect its acceptability” (p. 29).

Variyam and Blaylock (1998) suggest four categories of factors which influence food intake: consumers' incomes, food prices and the prices of other products

and services, consumers' knowledge of health and nutrition, and consumers' tastes and preferences. To change intake, one of these influences must change.

In the latter part of the twentieth century, knowledge of health and nutrition became sufficient to influence food selection, therefore in affluent countries such as the UK where physical and economic restraints are minimal, attempts may be made to influence food intake by improving nutrition knowledge through education (Webb, 2008).

Good levels of nutrition education will allow individuals to “access, assess and use information that is helpful to the attainment of good nutrition status” (Geissler, 2011). In other words, good nutrition knowledge will facilitate healthy food intake. So, does research suggest that there is a link between nutrition knowledge and food intake? Furthermore, does research suggest that improving nutrition knowledge will in turn improve food intake?

1.6. Research into relationship between nutrition knowledge and food intake.

1.6.1. Summary table of previous research (see Appendix 1 page i)

1.6.2. Historical studies

Two early investigations into the link between nutrition knowledge and food intake conducted in the United States suggested that nutrition knowledge may play a part in determining an individual's food attitudes and behaviours (Fusillo & Beloian, 1977; Werblow, Fox & Henneman, 1978). Positive correlations were

observed between nutrition knowledge and food shopping behaviour in a large group of adults (Fusillo & Beloian, 1977); and nutrition knowledge and attitude towards food in female athletes (Werblow, Fox & Henneman, 1978).

Later, Perron and Endres (1985) aimed to determine a link between nutrition knowledge and food intake by actually assessing food intake of female athletes using a 24 hour food recall and a 48 hour food record. Despite again finding a positive correlation between nutrition knowledge and attitude, no significant correlation was found between nutrition knowledge and food intake. Shepherd and Stockley (1987) also failed to find a correlation between nutrition knowledge and food intake in 210 UK adults as did Gracey, Stanley, Burke, Corti and Beilin (1996) in a study involving 15-16 year old students. Gracey et al. (1996) did however find a correlation between nutrition knowledge and the variety of food consumed.

These historical studies show that further investigation into the relationship between nutritional knowledge and food intake is warranted. However, close attention must be paid to the subjects and methods used. Perron and Endres (1985), Shepherd and Stockley (1987) and Gracey et al. (1996) all failed to find a correlation between nutrition knowledge and food and intake in three different studies involving three different subject groups. This may bolster the assertion that nutritional knowledge and food intake are not correlated as the findings are similar across groups of subjects with different demographics. However, in order to boldly assert the non-correlation, a comparison of results between studies that

use similar subject groups is also necessary. This is the case for other aspects of the methodology as well; assessment methods used for food intake and nutrition knowledge may be key in determining the results of the study. For example, despite their investigations yielding similar results, Perron and Endres (1985) used a 24 hour food recall and 48 hour food record whereas Gracey et al. (1996) determined usual intake of fatty foods intake using a 16 item questionnaire. These differing methods will yield differing results therefore rendering comparisons between the studies difficult to determine.

1.6.3. Intervention studies with child participants

Intervention studies involving children have generally found that nutrition knowledge and food behaviour or intake improve in the treatment group post-intervention. Shah et al. (2010) observed a significant improvement in results of a nutrition knowledge and food intake questionnaire and a significant, moderate positive correlation ($r = 0.687$) between nutrition knowledge and food intake when food intake was measured by assessing food behaviours with simple 'yes/no' questions. This form of assessment is problematic when measuring food intake as no quantitative data is available to the researchers; do the behaviours investigated accurately reflect food intake?

There are also other flaws in the study design which cast doubt on the results of Shah et al. (2010). Despite a large sample of 3128 children, no control group was used. Additionally, it is not known whether a pilot test of the food intake and

nutrition knowledge questionnaire showed the questionnaire to be valid and reliable.

Despite providing evidence of a relationship between nutrition knowledge and food intake, Shah et al. (2010) also demonstrates the use of an education intervention designed not only to improve nutrition knowledge but also designed to specifically improve the variable of food intake. For example, the intervention used techniques such as cooking competitions, healthy snack making and healthy recipe writing. Therefore, it cannot be assumed that the observed improvements in nutrition knowledge are driving the improvements in food intake; nutrition knowledge may have improved as a corollary of an educational intervention designed to improve food intake.

This corollary effect cannot be ruled out in the evidence provided by Powers, Struempler, Guarino and Parmer (2005). Following an education intervention, the treatment group showed significantly greater improvements in nutrition knowledge and food intake than the control group. Furthermore, a significant positive but very low correlation ($r = 0.098$) was observed between improvements in nutrition knowledge and improvements in food intake. A large treatment group of 702 participants may have facilitated in this weak correlation achieving significance.

As in Shah et al. (2010), Powers et al. (2005) did not measure food intake quantitatively and included, as part of the education intervention, techniques to

improve food intake such as eating with role models and learning skills to select healthy foods. Therefore the accuracy of the food intake assessment and value of nutrition knowledge in improving food intake are again questionable.

An intervention by Fahlman, Dake, McCaughtry and Martin (2008) assessed nutrition knowledge using a reliable (Cronbachs alpha > 0.7) questionnaire and food intake using 24 hour food recall. Although this method of food intake assessment would have yielded more quantitative data than that for Shah et al. (2010) and Powers et al. (2005) it may not give an accurate picture of a participants' general diet, thereby rendering the results invalid. In addition Fahlman et al. (2008) again used techniques to improve food intake as part of the education intervention. It is therefore perhaps unsurprising that the results were similar to those of Shah et al. (2010) and Powers et al. (2005) - nutrition knowledge and food intake were significantly better in the treatment group post-intervention compared to the control. Specifically, Fahlman et al. (2008) observed significant increases in fruit (2.48 servings/day pre-intervention versus 3.25 servings/day post-intervention) and vegetable (1.11 servings/day pre vs. 2.03 servings/day post) consumption in the treatment group whereas no significant differences were found in the control group for either fruit (2.52 servings/day pre vs. 2.41 servings/day post) or vegetable (1.38 servings/day pre vs. 1.22 servings/day post) consumption. Although significant, the observed changes in food intake are slight and the clinical relevance is minimal.

Kandiah and Jones (2002) perhaps provide the most well executed intervention study involving children. Dietary assessment was carried out using 3 day food records and nutrition knowledge was assessed using 25 multiple choice questions. This questionnaire had a Cronbachs alpha reliability score of 0.71 and the validity was approved by 5 separate nutrition professionals. Furthermore, the education intervention was designed purely to improve knowledge of recommended servings and the nutritional value of foods with no attention given to other techniques that could be used to improve food intake.

In a sample of 187 US fifth graders, the exercise group had a significant increase in nutrition knowledge score from 10.8 ± 2.7 to 14.6 ± 2.7 out of 25. The change in score and the score at post-test were both significantly greater than that in the control group in which the scores were 10.1 ± 0.5 at pre-test and 10.1 ± 2.2 at post-test. A significant difference between the two groups in the change in macronutrient intake and number of servings for various food groups was also observed. Carbohydrate intake increased in the experimental group (51.93% total calorie intake pre vs. 55.34% post) and decreased in the control (52.2% total calorie intake pre vs. 50.14% post) and fat intake decreased in the experimental group (32.86% total calorie intake pre vs. 29.20% post) and increased in the control (31.44% total calorie intake pre vs. 32.76% post) producing significant differences between the groups following the intervention. However, it is not reported whether or not the changes within the groups were significant; one must assume that the positive changes within the experimental group were not significant. Had carbohydrate and fat intake in the control group remained

constant or changed in the same direction as the experimental group instead of changing in the opposite direction as was observed, the changes between the groups may not have achieved significance.

The same is true for the changes observed in servings for various food groups. The number of servings of vegetables per day demonstrates this issue well: the control group had a large decrease from 1.7 servings/day to 0.6 servings/day whereas the experimental group had a small increase from 0.6 servings/day to 0.9 servings/day. There was a significant difference in servings/day between the groups post-intervention. However, the disparity in the pre-test measures coupled with not knowing the significance of the changes within the groups means one cannot be certain that the intervention had a positive impact on the participants' food intake.

1.6.4. Intervention studies with adult participants

Due to parents' influence, children will be subject to greater 'gatekeeper control' than adults (Webb, 2008). Therefore nutrition knowledge may not have as great an influence on a child's food intake as it would on that of an adult. Intervention studies involving adults have had similar results to those involving children. Valliant, Emplainscourt, Wenzel and Garner (2012) implemented a 4-month individualised nutrition education intervention with 11 female volleyball players and found that nutrition knowledge and food intake improved significantly following the intervention. Despite a small sample size, the reliable methods used for data collection such as between two and four three-day food records and the Reilly and Maughan Sports Nutrition Questionnaire give confidence that the

results are valid. Nutrition knowledge improved significantly from a mean score of 24.7 ± 5.9 out of 55 to 31.5 ± 6.1 and total energy intake for example increased significantly from a mean of 56% of estimated needs to 70%.

It is evident from this baseline measure of mean total energy intake that there was large potential to improve diet and the results may have been achieved by simply instructing the participants to eat more; the impact of improved nutrition knowledge on the outcomes is questionable. Furthermore, during the 4-month intervention participants made a 3-day food record once a month. This would have allowed the participants to monitor their food intake and alter as necessary during the intervention again casting doubt on the influence of nutrition knowledge. Indeed there is evidence to suggest that monitoring food intake is a means by which to improve food intake.

1.6.5. Cross-sectional studies

Intervention studies show that nutrition education may improve nutrition knowledge and food intake but is there a correlation between these two variables? Cross-sectional studies may be able to provide an answer. The results from studies involving young adult athletes are equivocal. Rash, Malinauskas, Duffin, Barber-Heidal and Overton (2008) found a significant very low positive correlation ($r = 0.001$) between diet quality and nutrition knowledge; Walsh, Cartwright, Corish, Sugrue and Wood-Martin (2011) found that good knowledge was generally not related to good nutrition behaviours apart from hydration

practices; and Hoogenboom, Morris, Morris and Schaefer (2009) found no relation between nutrition knowledge and food intake.

Rash et al. (2008) probably represents the strongest study design and therefore the most robust results. 113 participants (61 male and 52 female) had their food intake assessed using a semi-quantitative 12-month food frequency questionnaire and nutrition knowledge assessed using a questionnaire concerning carbohydrate, protein, vitamins and minerals. The results were correlated using simple linear regression which gives a clear indication of the relationship between food intake and nutrition knowledge.

Contrast this with Hoogenboom et al. (2009) who used the more unreliable method of 24 hour recall to assess food intake and analysed their results by comparing mean nutrition knowledge scores of those who had a good diet to those who had a poor diet as judged by compliance to RDAs. This does not give a clear indication of the relationship between nutrition knowledge and food intake, especially when only 9% of participants fall into the good diet group and 91% are in the poor diet group.

Walsh et al. (2011) in their study of 203 rugby players also present results that do not clearly demonstrate the relationship between nutrition knowledge and food intake. Mean knowledge scores related to percentage of participants involved in good dietary practices ignores the range of knowledge scores and the effect that outliers can have on the mean. Furthermore, the behaviours of individual team members are likely to be influenced by coaches and by general team behaviours.

Therefore the true effect of nutritional knowledge may not be seen in these participants.

Despite the strengths of Rash et al. (2008), the validity and reliability testing of the nutrition knowledge questionnaire was limited as was the questionnaire in its assessment of overall nutrition knowledge. Fibre, saturated fat and cholesterol were not included in the questionnaire even though the intake of each was assessed. In addition, sucrose was the only carbohydrate intake measured despite the questionnaire assessing overall knowledge of carbohydrates. Therefore the very low correlation between nutrition knowledge and food intake ($r = 0.001$) begins to look inconsequentially low.

Cross-sectional studies using participants from the general population are perhaps the best means by which to investigate the relationship between nutrition knowledge and food intake as there are no specific nutritional requirements and related knowledge. Pieniak, Verbeke and Scholderer (2010) conducted a very large but simple study concerning nutrition knowledge and fish consumption. 4786 European adults were asked to report their fish consumption using a 9-point Likert scale ranging from 'never' to 'daily or almost everyday'. Nutrition knowledge of fish was assessed using 4 true/false questions. Knowledge was found to have a weak positive correlation with fish consumption (r value not reported).

Pieniak, Verbeke and Scholderer (2010) demonstrate a relationship between knowledge and intake but there are flaws in a simple study of one food type. Although fish consumption was perhaps chosen as a variable as it is seen as a healthy practice and may relate to health consciousness or health awareness in a way that potato or bread consumption, for example, may not; there are factors which may override health consciousness or health awareness and influence fish consumption in a way that would not influence potato or bread consumption. For example, fish consumption could be affected by one's proximity to the sea or access to a fresh fish market. Furthermore, the type of fish consumed was not taken into account. It is possible that those with higher nutrition knowledge did not consume as much fish as others but consumed healthier varieties, such as oily fish which are known to have more health-promoting properties.

4 nutrition knowledge questions used by Pieniak, Verbeke and Scholderer (2010) were probably not enough to get a good picture of participants' nutrition knowledge or to provide a range of scores sufficient to generate a high correlation with fish consumption. A study by Dallongeville, Marecaux, Cottel, Bingham and Amouyel (2001) suffers from the same shortcoming. However, the nutrition knowledge questionnaire used by Dallongeville et al. (2001) is slightly longer at 10 questions and the more detailed and reliable method of 3 day food records was used to assess food intake. These factors give more credence to the results of Dallongeville et al. (2001) who also observed a relationship between nutrition knowledge and food intake in 361 middle-aged men. Specifically, intakes of total fat and monounsaturated fat of animal origin were significantly lower in those

whose nutrition knowledge score was more than or equal to 7 out of 10 compared to those whose nutrition knowledge score was less than or equal to 4 out of 10. This result suggests an improvement in food intake with improved nutrition knowledge. However, the total fat intake of those in the high score group was still high (89 ± 24 g/day) and contributed 40% to total calories. Therefore the clinical importance of nutrition knowledge with regard to a healthy diet is questionable in relation to the results of Dallongeville et al. (2001).

Evidence of a correlation for more than one macronutrient is needed to firmly suggest a correlation between nutrition knowledge and food intake. This evidence is provided by Beydoun, Powell and Wang (2009) in a study of 4252 adult males and females aged between 20 and 65. Overall diet quality was assessed using the United States Department of Agriculture's (USDA) Healthy Eating Index (HEI) and found to have a linear dose-response relationship with nutrition knowledge. Furthermore, when participants were divided into tertiles based on nutrition knowledge score, the lowest tertile had significantly higher intakes of total fat and saturated fat (86.8 ± 2 g/day vs. 69.9 ± 1.6 g/day; 29.5 ± 0.7 g/day vs. 23 ± 0.5 g/day) and significantly lower intakes of fruit and vegetables and fibre (4.8 ± 0.1 servings/day vs. 5.1 ± 0.1 servings/day; 15.5 ± 0.3 g/day vs. 16.8 ± 0.4 g/day) compared to the highest tertile. This suggests that those with higher nutrition knowledge have a healthier diet. However it should be noted that nutrition knowledge assessment in this study leaned towards assessing dietary attitudes rather than knowledge of food composition and which foods represent healthy choices. Therefore despite the large and heterogeneous sample and reliable

dietary assessment method (2 x 24 hour recall) the value of Beydoun, Powell and Wang (2009) as support for a correlation between diet and nutritional knowledge is questionable. Furthermore, numerous tests for difference were carried out on the data and there is no mention of a Bonferroni adjustment being applied. Therefore, the chances of making a type I error are increased.

However, further evidence of a correlation is provided by Wardle, Parmenter and Waller (2000). In a cross-sectional study of 455 men and 584 women with an average age of 51 ± 5 years, nutrition knowledge showed a moderately low positive correlation with vegetable intake ($r=0.36$) and fruit intake ($r=0.23$) and a moderately low negative correlation with fat intake ($r=-0.21$). In this study, nutrition knowledge was assessed using the Parmenter and Wardle (1999) Nutrition Knowledge Questionnaire (NKQ) which is a very comprehensive questionnaire consisting of 110 items covering expert recommendations, nutrient content of food, everyday food choices and diet-disease relationships. The validity and reliability of the NKQ were found to be good and acceptable (Parmenter and Wardle, 1999). This assessment method inspires confidence in the validity of the nutrition knowledge scores in Wardle, Parmenter and Waller (2000). However, the food intake assessment is perhaps less valid as it only assessed frequency of intake and not quantity. Despite this, Wardle, Parmenter and Waller (2000) provides perhaps the most compelling evidence of a correlation between nutrition knowledge and food intake.

In all of the aforementioned intervention studies nutrition knowledge and food intake or food behaviours improve post-intervention. Cross-sectional studies provide some evidence for a correlation between nutrition knowledge and food intake, however, it cannot be assumed that improvements in nutritional knowledge are driving the improvements of food intake; nutritional knowledge may have improved as a corollary of an educational intervention designed to improve food intake. More evidence is needed to establish a causal effect of nutrition knowledge. Furthermore, confounding factors must be taken into account which could also affect the relationships observed in cross-sectional correlational studies.

1.7. Confounding factors: attempting to isolate the effect of nutrition knowledge

Nutrition knowledge and diet quality have been shown to have a positive correlation with income and education (Dallongeville et al., 2001; Gracey et al., 1996; Klohe-Lehman et al., 2006; Wardle, Parmenter & Waller, 2000). Relationships with age and race have also been observed (Klohe-Lehman et al., 2006; Wardle, Parmenter & Waller, 2000). Therefore it is possible that the association between nutrition knowledge and food intake observed in the studies mentioned herein is caused by their both being correlated with demographic characteristics. To test for this some studies have produced regression models to account for confounding factors. Wardle, Parmenter & Waller (2000) found that nutrition knowledge mediated the effect of education and occupational class on fruit and vegetable intake, although no such mediation was observed for fat

intake. However, Dallongeville et al. (2001) provide evidence of a mediation effect of nutrition knowledge on fat intake in men at least as they observed significantly higher fat intake in a low nutrition knowledge group (104 ± 38 g/day) compared to a high nutrition knowledge group (89 ± 24 g/day) when adjustment was made for educational and socio-economic variables as well as age.

The relationship between nutrition knowledge and food intake is a complex one. There are many factors besides nutrition knowledge which affect food intake meaning it is difficult to isolate the influence that nutrition knowledge has. The evidence reviewed herein suggests that nutrition knowledge can have an effect on food intake although knowledge is itself linked to other food intake determinants. However, these other determinants such as age, education and socio-economic status are not readily changed therefore improving nutrition knowledge may be the most efficient method by which to improve food intake.

1.8. Conclusion

In the developed world, despite limited threat to food security and availability, poor diets are contributing to the burden of chronic disease. Research suggests that nutrition knowledge may be implicated in the cause and prevention of poor diets. Furthermore, nutrition knowledge can be improved in order to improve diet quality and mediate the negative influence of education and socioeconomic status. Therefore nutrition education may have the potential to combat the trend of worsening diet related health evident in today's society.

There is evidence to suggest that nutrition education is a positive intervention, however the long-term effects of an intervention require further investigation as does the persistence into adulthood of a successful childhood education intervention.

Each study reviewed herein has its flaws and limitations whether they be small sample size, poor data handling, inadequate assessment methods, clinically irrelevant results, poor study design, author bias or a general lack of control over the research methods. However, consistent demonstration of a relationship between nutrition knowledge and food intake suggests that a real relationship does exist. The size of effect and the clinical significance are the critical issues. Most significant correlations demonstrated in cross-sectional studies are weak and perhaps not enough to encourage greater nutrition education. Furthermore, cross-sectional evidence with regard to protein and total calorie intake is lacking.

However, if a large body of cross-sectional evidence is built-up and future intervention studies can be designed robustly and continue to produce positive results, nutrition education may become a potent weapon in the fight against chronic disease. It is therefore the objective of the following research to add to the body of evidence by testing the hypothesis that nutrition knowledge is significantly correlated to food intake; specifically total calorie, carbohydrate, fat, protein and fibre intake.

2. Is nutrition knowledge related to food intake in free-living adults?

Key words: macronutrients, fibre, correlation, health

2.1. Appropriate journal

With an impact factor of 3.302 the British Journal of Nutrition is a reputable publication with a 66 year history. The journal aims to develop nutritional concepts which is in mind with the current study. In the current format, the research presented adheres to the guidelines set out by the journal bar a few cosmetic adjustments. To be published in a British journal would be seen to be at the forefront of science.

2.2. Abstract

The determinants of food intake are varied and share complex relationships. Nutrition knowledge may be one such determinant that has a correlation with food intake. To investigate this correlation, a sample of 22 adults aged 18-64 were recruited from the general population. Nutrition knowledge was assessed using the Parmenter and Wardle (1999) Nutrition Knowledge Questionnaire (NKQ) and food intake was assessed by 3 day food records which were recorded by the participants using a smartphone application. NKQ score was correlated with intake of calories, fat, carbohydrate, protein and fibre in three variations: total intake, percentage of recommended intake and deviation from recommended. T-tests were used to analyse the difference in NKQ scores with regard to adherence to recommended intakes of calories, carbohydrate, protein and fibre. A significant correlation was found between NKQ score and deviation from recommended carbohydrate intake ($r = -0.591$, $p = 0.008$). A significant difference ($p = 0.047$) in NKQ score was found between those with fibre intakes above 18

g/day (68.5 ± 13.8) and those below 18 g/day (58.08 ± 8.8). Nutrition knowledge was significantly related to food intake. Nutrition education may be a means by which to improve food intake and therefore health.

2.3. Introduction

According to food intake models, nutritional knowledge is one of a number of possible determinants of food intake (Variyam and Blaylock, 1998; Webb, 2008). However, evidence from research is not unanimous. Therefore, in spite of studies that show nutrition education can improve nutritional knowledge (Powers, Struempler, Guarino & Parmer, 2005; Shah et al., 2010), the value of nutrition education is questionable.

Previous studies have failed to establish a link between nutritional knowledge and food intake due to the complex nature of nutritional knowledge and the numerous factors which affect food intake. When taking nutritional knowledge as an independent variable it is evidently difficult to control confounding factors (Dallongeville, Marecaux, Cottel, Bingham & Amouyel, 2001; Klohe-Lehman et al., 2006). Furthermore, the study design and assessment methods of a number of previously published studies have not been robust enough to provide reliable results (Dallongeville et al., 2001; Pieniak, Verbeke & Scholderer, 2010).

However, a slight effect of nutritional knowledge on food intake is often observed. Therefore, if a large body of evidence can be built, it would be reasonable to assert that nutritional knowledge is positively correlated with food intake and that

nutrition education can improve food intake as has been demonstrated by Powers, et al. (2005).

It is the objective of this study to contribute evidence in relation to a link between nutritional knowledge and food intake with a view to determining the benefits of nutrition education.

2.4. Methods

2.4.1. Study Design

This was a non-experimental, correlational, cross-sectional study designed to investigate the relationship between nutritional knowledge (independent variable) and food intake (dependent variable). Assessments of nutritional knowledge and food intake were carried out with the results being correlated in order to determine a link between the variables or lack thereof. Participants were adult volunteers from whom written informed consent was obtained. Ethical approval was granted by the Faculty of Applied Sciences Research Ethics Committee of the University of Chester.

2.4.2. Participants

25 Participants were recruited via advertisements on social networking site Facebook, plus advertisements in the Maidstone offices of Kent County Council and in the warehouse of a distribution company based in Marden, Kent. Potential participants were screened with a questionnaire to determine whether they met

the following inclusion criteria: aged between 18 and 64, user of a smartphone or tablet, no nutritional training or qualifications, not currently following a specialised diet plan, not currently undertaking a planned weight loss regime, not currently using the smartphone app. or similar, not living with parents (i.e. not responsible for food choices).

Eligible participants were provided with a Participant Information Sheet (PIS) concerning the rationale for and the design of the study as well as what was to be required of them. Participants were asked to sign the PIS to signal their willingness to proceed before the trial commenced.

2.4.3. Nutritional Knowledge Assessment

The Nutritional Knowledge Questionnaire (NKQ) developed and described in detail by Parmenter and Wardle (1999) was used to assess participants' nutritional knowledge. The questionnaire consisted of 99 items: 69 concerning knowledge of sources of foods and nutrients; 10 concerning choosing everyday foods and 20 concerning diet-disease relationships. A score out of 99 was awarded to each participant and used for analysis.

The NKQ was adapted to an electronic on-line format using the website www.surveymonkey.com allowing participants to complete the NKQ at their convenience.

NKQ responses were downloaded from the survey monkey website and saved to a spreadsheet using Microsoft Excel for Windows 8. The total of correct answers for each participant was calculated and used for analysis

2.4.4. Dietary Assessment

Participants were asked to record three days of food intake (to include one weekend day and two weekdays) using the 'Fat Secret Calorie Counter' app for tablets and smartphones. This app enables users to enter food manually, choose from a database of foods and scan barcodes of food eaten in order to input nutrition information. Daily intake of total calories, carbohydrate, fat, saturated fat, protein, fibre, cholesterol, sodium and potassium is calculated and stored by the application (saturated fat, cholesterol, sodium and potassium data will not be used for analysis). Intake data can be sent from the smartphone or tablet to an e-mail address using a function of the app. A guide on how to use this function was provided to each participant. Participants were also provided with a guide on recording food intake which included advice on calculating portion sizes, avoiding common errors and omissions and making accurate entries.

Mean daily intakes were calculated for total calories, carbohydrate, fat, saturated fat, protein, fibre and sodium. Macronutrient calorie intake as a percentage of total calorie intake was calculated using Atwater factors. In addition, the percentage deviation from FSA (2006) recommended intakes of total calories (2500 for men, 2000 for women), carbohydrate (50% of total calories) and protein (55 grams per day) was calculated for each participant.

2.4.5. Experimental Procedure

To begin the trial, participants were e-mailed a link to the NKQ and asked to complete at their earliest convenience before proceeding with the rest of the trial. Reminders were sent to those participants who had not completed the NKQ within a week of receiving the link.

Once all responses had been collected, participants were given the name of the app and asked to download and install. An e-mail address was also provided to which completed three day food records should be sent. Participants were instructed to begin recording food intake from the day following app installation.

On completion of a three day food record, participants e-mailed food intake data to the lead researcher and data was copied and pasted into a Microsoft Excel spreadsheet for intake calculations to be carried out.

2.4.6. Data Analysis

Microsoft Excel spreadsheets were used to manage raw data. NKQ scores, mean intakes, macronutrient percentages and percentage deviations were entered into SPSS version 22 for Windows which was used for statistical analysis.

A Shapiro-Wilk test for normality of distribution was carried out on NKQ scores, food intake means, macronutrient percentages and percentage deviations.

Correlations between NKQ score and each of the intake variables was examined using Pearson's Product Moment or Spearman's Rank Correlation Coefficient depending on the result of a normality of distribution test.

Further analysis of the relationships between NKQ score and fibre, protein, carbohydrate and total calorie intake was conducted by grouping participants according to their intakes in relation to FSA (2006) recommendations.

Participants were grouped as either being under or equal to/above the recommended intake. The recommended intakes used were: fibre - $18 \text{ g} \cdot \text{day}^{-1}$; protein - $55 \text{ g} \cdot \text{day}^{-1}$; carbohydrate - 50% of total calories; total calories - 2500 for men and 2000 for women.

With regard to total calorie intake a 25% deviation from the recommendation was still considered a healthy intake. A 25% deviation limit was chosen in an attempt to allow for healthy individual intakes that deviated from the recommended intake. For example, a man with an active lifestyle would probably require more than 2500 calories per day in order to remain weight stable so an intake above the recommended intake would still be considered healthy in his case.

Following tests for homogeneity and normality of distribution, independent t-tests were used to compare the groups mean NKQ scores. A significance level of $p = \leq 0.05$ was used throughout.

2.5. Results

A response rate of 88% (N=22) was achieved comprising 10 men and 12 women. The age ranges of participants can be seen in Table 1 below, the 25-34 age group was most highly represented (N=10). All participants were of white ethnic origin.

Table 1. Number of participants in each age group.

	18-24	25-34	35-44	45-54	55-64
<i>Men</i>	2	5	1	1	1
<i>Women</i>	2	5	2	1	2
Total	4	10	3	2	3

Of the final sample (N=22) saturated fat intake was not obtained for participant 10 and participant 21; fibre and sodium intake were also not obtained for participant 10. Therefore, N=21 for analysis of fibre and sodium intake data and N=20 for analysis of saturated fat intake data.

Nutrition knowledge score ranged from 44 to 90 out of 99. The range of scores is demonstrated in Figure 1.

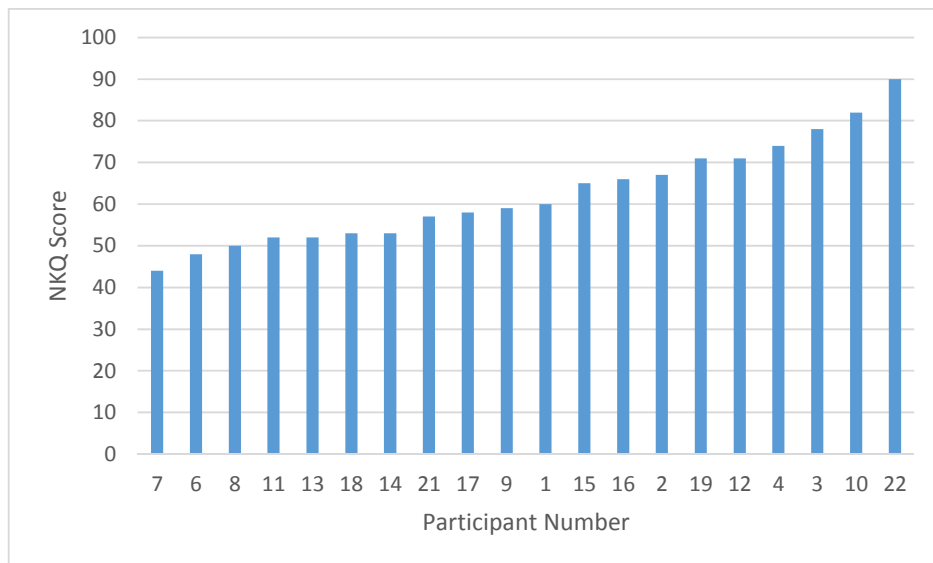


Figure 1. Graph to show NKQ scores of each participant; x- axis arranged to display scores from lowest on the left to highest on the right.

Table 2 shows that the only statistically significant correlation was a moderate negative correlation between NKQ score and deviation from recommended carbohydrate intake ($r = -0.591$, $p = 0.008$). This correlation is visually presented in Figure 2 showing that as NKQ score increased, deviation from recommended carbohydrate decreased.

Table 2. Correlation coefficients for dietary intake variables against NKQ score.

Intake Variable	Correlation with NKQ score		P value
	Pearson's Product Moment r value	Spearman's Rank Correlation Coefficient r value	
Total Calories	-0.001		0.997
Percentage of recommended calories	-0.073		0.748
Macronutrient calories:			
Fat		0.298	0.177
Carbohydrate	-0.144		0.522
Protein	0.096		0.670
Deviation from recommended intake [#] :			
Total calories	-0.391		0.072
Carbohydrate	-0.549		0.008*
Protein		-0.244	0.275
Fibre	0.216		0.347

* denotes significance at the $p = \leq 0.05$ level

[#] FSA (2006) recommended intakes: total calories - 2500 for men, 2000 for women; carbohydrate - 50% of total calories; protein - 55 g•day⁻¹

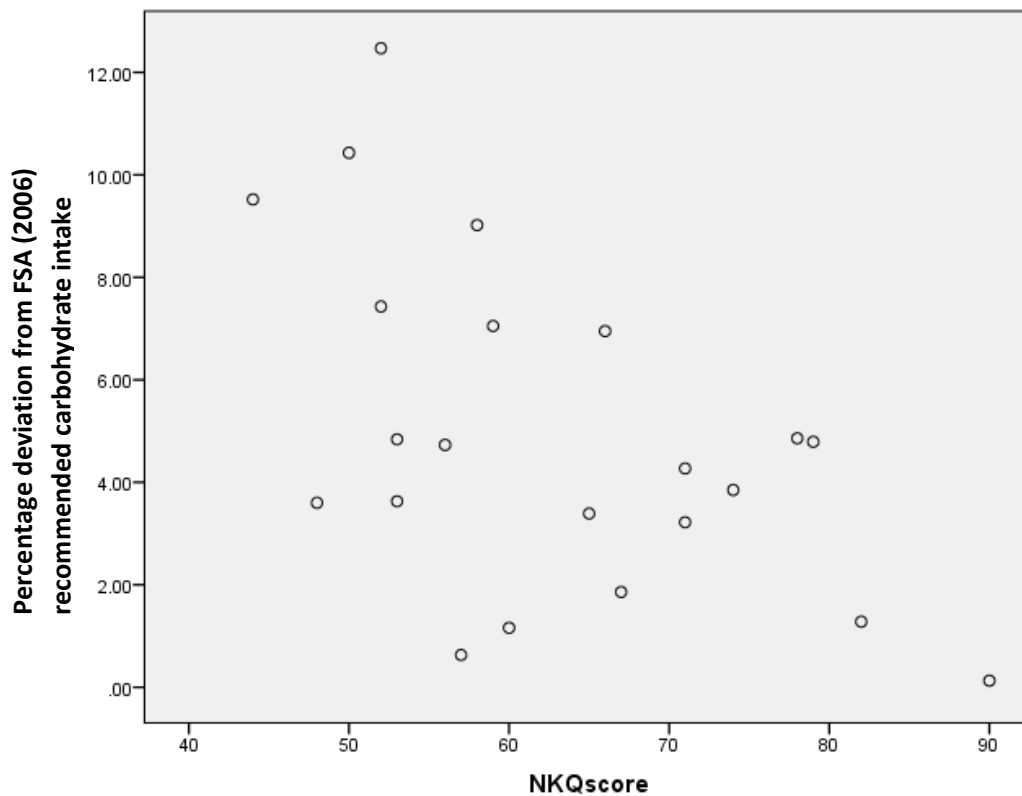


Figure 2. Scatter plot to show correlation between NKQ score and percentage deviation from recommended carbohydrate intake.

Table 3 shows that when the participants were split into two groups according to their intake in relation to recommended intake there was a statistically significant difference in mean NKQ score between those with fibre intakes below 18 grams per day and those with fibre intakes equal to/above 18 g/day (58.08 ± 8.8 vs. 68.5 ± 13.81 , $p = 0.047$).

Table 3. Mean NKQ scores when participants were grouped as either below or equal to/above FSA (2006) recommended intake for carbohydrate, protein and fibre; and either within or not within 25% of recommended calorie intake.

Intake Variable	Recommended Intake	Mean NKQ Score		P value for t-test of difference in mean scores
		<i>Below recommended intake</i>	<i>Equal to/above recommended intake</i>	
Carbohydrate	50% total kcal	61 ± 2.74	64.31 ± 4.07	0.738
Protein	55 g/day	60.91 ± 12.23	65 ± 12.63	0.449
Fibre	18 g/day	58.08 ± 8.8	68.5 ± 13.81	0.047*
Recommended calorie intake	Men:2500 Women:2000	<i>Not within 25%</i> 60.54 ± 11.77	<i>Within 25%</i> 66.44 ± 12.91	0.279

* denotes significance at the $p = \leq 0.05$ level

2.6. Discussion

2.6.1. Main findings

The results of this study suggest that nutrition knowledge has an effect on certain aspects of an individuals' food intake. In a sample of adults from the general population, nutrition knowledge had a significant negative correlation with adherence to recommended carbohydrate intake ($r = -0.591$, $p = 0.008$). In addition, an effect for fibre intake was observed - there was a significant difference in nutrition knowledge scores between those that consumed under the recommended daily intake for fibre and those that consumed equal to or above

the recommended daily intake (58.08 ± 8.8 vs. 68.5 ± 13.81 , respectively $p = 0.047$).

These results suggest that as nutrition knowledge increases, adherence to FSA (2006) recommended carbohydrate intake improves so that individuals with high nutritional knowledge will consume or will be very close to consuming the recommended proportion of 50% of calories from carbohydrate (Figure 2). In addition, individuals with a higher nutritional knowledge are more likely to consume at least the recommended daily intake of $18 \text{ g} \cdot \text{day}^{-1}$ of fibre. In this case a higher nutrition knowledge is equal to a mean score of 68.5 out 99 and is on average 10 marks higher than those below recommended daily intake of $18 \text{ g} \cdot \text{day}^{-1}$ of fibre.

2.6.2. Main findings in relation to previous research

The significant findings of the current study are in accordance with those of others which have also demonstrated relationships between nutrition knowledge and food intake (Beydoun, Powell & Wang, 2009; Dallongeville et al., 2001; Pieniak, Verbeke & Scholderer, 2010; Wardle, Parmenter & Waller, 2000). In relation to the significant results of the current study, Beydoun, Powell and Wang (2009) demonstrated an increase in fibre intake as nutrition knowledge increases. Furthermore, fruit and vegetable intake, which would make a substantial contribution to fibre intake, has been shown to increase as nutrition knowledge increases (Fahlman, Dake, Mcaughtry & Martin, 2008; Kandiah & Jones, 2002;

Wardle, Parmenter & Waller, 2000) suggesting a real and consistent effect of nutrition knowledge on fibre intake. However, no correlation between nutrition knowledge and fibre intake in the current study was found ($r = 0.216$, $p = 0.347$) which perhaps suggests that achieving nutrition knowledge of a certain level is key to achieving recommended fibre intake. Therefore increasing nutrition knowledge via nutrition education may be a means by which to improve fibre intake as has been demonstrated previously (Fahlman, Dake, Mcaughtry & Martin, 2008; Kandiah & Jones, 2002)

Kandiah & Jones (2002) also observed an increase in grain and milk consumption and a subsequent improvement in carbohydrate intake in line with an increase in nutrition knowledge, supporting the current finding of a significant negative correlation between nutrition knowledge and adherence to recommended carbohydrate intake. However, previous research provides little evidence to corroborate this correlation. This is perhaps due to the difficulty in defining and measuring a healthy carbohydrate intake. In addition, the majority of previous studies have focused on intakes of fruit, vegetables and fats probably because intake of these is most directly linked to physical health; indeed a reduction in fat intake has been observed with an increase in nutrition knowledge (Dallongeville, 2001; Wardle, Parmenter & Waller, 2000). With this in mind, the results of the current study perhaps suggest that an increase in carbohydrate intake may compensate for the decrease in fat intake observed in previous studies.

2.6.3. Null findings in relation to previous research

However, despite a correlation between carbohydrate intake and nutrition knowledge observed in the current study a compensatory shift in fat or protein intake cannot be demonstrated. No correlation was found between nutrition knowledge and fat intake ($r = 0.298$, $p = 0.177$) or protein intake ($r = 0.096$, $p = 0.670$). These null findings are contrary to many previous studies where relationships have been observed (Beydoun, Powell & Wang, 2009; Dallongeville, 2001; Wardle, Parmenter & Waller, 2000) although Hoogenboom, Morris, Morris and Schaefer (2009) failed to observe an effect of nutrition knowledge with regard to macronutrient contribution to total calories.

The current study also failed to find a relationship between nutrition knowledge and total calorie intake ($r = -0.001$, $p = 0.997$), percentage of recommended calorie intake ($r = -0.073$, $p = 0.748$) and deviation from recommended intake ($r = -0.391$, $p = 0.072$). Valliant et al. (2012) observed that following a nutrition education intervention, calorie intake moved significantly towards an intake which matched energy needs suggesting that a correlation between nutrition knowledge and calorie may exist. In the current study, when deviation from recommended calorie intake was correlated with nutritional knowledge a correlation was observed however this failed to achieve significance ($r = -0.391$, $p = 0.072$). This correlation may have achieved significance had the sample been larger, in which case support would have been provided for the finding of Valliant et al. (2012).

However, an insignificant result as was observed in the current study suggests no relationship between nutrition knowledge and calorie intake - a finding which is in accordance with previous observational studies (Bravo, Martin & Gonzalez, 2006). Furthermore, when the current sample was split according to deviation from recommended calorie intake (Table 3) no significant difference in mean NKQ score was found between those who had intakes within 25% of the recommended calories those who had intakes outside 25% of recommended total calories (66.44 ± 12.91 vs. 60.54 ± 11.77 respectively, $p = 0.279$). This is further evidence that the current study does not support a relationship between nutrition knowledge and calorie intake.

2.6.4. Limitations and Flaws

The failure of the current study to demonstrate significant results for fat and protein intake may be due to the measures used to represent healthy intakes. The FSA (2006) provides a recommended percentage of total calories for carbohydrate intake (50%). Therefore deviation above or below this figure represents a move towards an unhealthy diet with diet becoming less healthy as the deviation increases, allowing percentage contribution of carbohydrate to total calories to be used as an indicator of diet quality.

The FSA (2006) recommendations for fat intake are a maximum percentage of total calories (35%) and not a target percentage as in the case for carbohydrate. Therefore deviation from the maximum percentage for fat intake is not an

accurate indicator of diet quality - intakes above 35% would be considered unhealthy whereas intakes below 35% would be considered healthy until intake is well below 35% in which case fat intake may be too low to be considered healthy. For this reason deviation from maximum percentage of total calories from fat was not used for analysis in the current study and therefore a ratio to carbohydrate intake could not be calculated.

Instead, the percentage contribution of fat to total calories was correlated with nutrition knowledge as a further measure of diet quality. However a significant correlation was not demonstrated ($r = 0.298$, $p = 0.177$). This is perhaps because the vast majority of participants consumed less than the maximum recommended fat intake i.e. a healthy intake. Furthermore due to the body's requirement for the essential fatty acids, a zero fat diet would not be considered healthy and a scale of increasing fat intake uniformly from zero does not represent increasing diet quality as there comes a point where fat intake becomes too high to be considered healthy. Therefore percentage contribution of fat to total calories as used in the current study is not a suitable test variable nor is it an accurate indicator of a healthy diet. Hence, percentage contribution of fat to total calories was not suitable to use in a correlation with nutrition knowledge when testing the hypothesis that nutrition knowledge is positively correlated with a healthy diet. Further study should perhaps employ a fat score as used developed by Kinlay et al. (1991).

A similar situation is presented for protein intake. Although protein intake should equate to approximately 15% of total calories which would allow for calculation of

deviation to represent unhealthy intake, due to protein turnover the body has a specific requirement for protein. The FSA (2006) recommends $55 \text{ g} \cdot \text{day}^{-1}$ of protein for the adult sample in the current study. Therefore 15% of a low calorie diet will probably not provide enough protein for the body's requirements and represent an unhealthy intake which is why 15% protein intake was not used as an indicator of a healthy diet in the current study.

As $55 \text{ g} \cdot \text{day}^{-1}$ of protein is recommended, deviation from this value was calculated for each participant and used to represent unhealthy intake. However, deviation from recommended protein intake did not demonstrate a significant negative correlation with nutrition knowledge as carbohydrate did. Protein deviation demonstrated a moderately-low negative correlation ($r = -0.244$) with nutrition knowledge, however this did not achieve significance ($p = 0.275$).

The lack of a significant negative correlation between nutrition knowledge and deviation from recommended protein intake may be due to knowledge that intake above $55 \text{ g} \cdot \text{day}^{-1}$ is not considered unhealthy. There is little evidence to suggest that protein intakes above 1.2 grams per kilogram of body mass per day ($\text{g} \cdot \text{kgBM} \cdot \text{day}^{-1}$) are detrimental to health (Paddon-Jones, Short, Campbell, Volpi & Wolfe, 2008). Participants with good nutrition knowledge may have had protein intakes of protein way above $55 \text{ g} \cdot \text{day}^{-1}$ in the knowledge that it poses no threat to health. The FSA (2006) does not recommend a maximum protein intake and there is little evidence to suggest that protein intakes above are unhealthy. Therefore if a correlation between nutrition knowledge and a healthy diet does exist, it will not be demonstrated by a correlation using deviation from the

recommended protein intake of $55 \text{ g} \cdot \text{day}^{-1}$ as was used in the current study. For this reason, further analysis was applied to protein intake data, the results of which can be seen in Table 3. No significant difference ($p = 0.449$) in NKQ score was found between those that ate below $55 \text{ g} \cdot \text{day}^{-1}$ of protein (60.91 ± 12.23) and those that ate equal to or above $55 \text{ g} \cdot \text{day}^{-1}$ (65 ± 12.63). This may be due to the average protein intake of the UK population as a whole being well above $55 \text{ g} \cdot \text{day}^{-1}$ (Bates, Lennox, Bates & Swan, 2011) suggesting that protein intake is not limited by factors which limit intakes of other nutrients.

With regard to total calorie intake, there are flaws in the assessment methods of current study which may have affected the results. In order to obtain an accurate and valid measurement of recommended intake and deviation from recommended intake, the design of the current study would require an individual recommended intake to be calculated for each participant instead of using arbitrary values of 2500 calories for men and 2000 calories for women. This would require the collection of height, weight and exact age data as well as physical activity information which was not collected for the current study. Further study should take these variables into account and continue to investigate the relationship between nutrition knowledge and calorie intake. Current evidence is limited and excessive calorie intake is currently a major health issue which requires understanding and addressing.

In addition to the aforementioned flaws, there are a number of limitations to the current study. Firstly the sample size was small for what was intended to be a representation of the general adult population. A sample of this size may not have

had the power to detect the size of effect necessary to produce significant results where true and real results existed (Crombie, 1996). Secondly, participants aged 24-35 made up 45% percent of the sample which is not representative of the general population (Office for National Statistics [ONS], 2013) and therefore limits the dissemination of the results. Furthermore, the large proportion of participants aged 24-35 and only 2 aged 45-54 casts doubt on the validity and reliability of analysis using age as a variable. Thirdly, numerous statistical tests were carried out on just one dataset which means there is potential to “encounter spuriously significant results” (Crombie, 1996, p. 15).

2.6.5. Confounding factors

As an extension to limitations and flaws - confounding factors - must be taken into account. Due to confounding factors that affect food intake, it is possible that the significant relationships between nutrition knowledge and food intake observed in the current study are caused by an external factor such as age, gender or socio-economic status. Previous studies have found that demographic factors are related to nutrition knowledge and food intake but also that the relationship between nutrition knowledge and food intake persists when confounding factors are controlled (Beydoun, Powell & Wang, 2009; Wardle, Parmenter & Waller, 2000). In the current study, neither of the significant findings had a relationship with demographic factors when tested for by independent t-test (gender) or by correlation coefficient (age group). Interestingly, NKQ score showed a moderate

positive correlation with age ($r = 0.494$, $p = 0.019$). This finding gives more credence to the relationships demonstrated in the current study by suggesting that nutrition knowledge may have over-ridden the effect of age with regard to carbohydrate and fibre intake.

Despite these findings, other confounding factors such as level of general education and socio-economic status which have been shown to affect nutrition knowledge and food intake (Beydoun, Powell and Wang, 2009; Dallongeville et al., 2001) were not accounted for in the current study and so their influence cannot be ruled out. Further study to collect and analyse information on confounding factors for the current sample group would be of interest to investigate the relationships within the study.

2.6.6. Clinical relevance of results

The relationship between carbohydrate and nutritional knowledge perhaps does not have the greatest clinical relevance. Although adherence to the recommended intake could be judged as a healthy intake, the type of carbohydrate consumed is of great importance - 50 % of total calories as carbohydrate would not be considered a healthy intake if sugar was a high proportion of carbohydrate intake. Furthermore, the diet beyond carbohydrate intake must be healthy. A total carbohydrate intake of the recommended proportion is of little benefit if other dietary components such as total calorie intake and fat intake are at an unhealthy level. However, excessively high or low

carbohydrate intakes do have health implications such as increased risk of non-insulin-dependent-diabetes and ischemic heart disease (Jeppesen, Schaaf, Jones, Zhou, Chen & Reaven, 1997; Marshall, Hamman, Baxter, 1991); therefore the finding of the current study that deviation from recommended carbohydrate intake is negatively correlated with nutrition knowledge suggests that nutrition education may be clinically important.

The finding that fibre intake is related to nutrition knowledge is certainly of clinical relevance: consuming at least $18 \text{ g} \cdot \text{day}^{-1}$ of fibre is of benefit to the general population. Previous studies have shown that low fibre intake is related to a number of health issues (Anderson et al., 2009; Lindstrom et al., 2006) therefore increasing fibre intake may be a potential means of combating these issues. The results of the current study suggest that improving nutrition knowledge may be a means by which to increase fibre intake and therefore reduce the risk of developing fibre deficiency illnesses.

Nutrition education may therefore be a plausible intervention for increasing fibre intake. Indeed previous education intervention studies involving children have found that fruit and vegetable intake (key contributors to fibre intake) have increased post-intervention (Fahlman, Dake, Mcaughtry & Martin, 2008; Kandiah & Jones, 2002).

Education interventions using adult participants warrant further study. With a sample of volleyball players aged between 19 and 22 Valliant et al. (2012) observed improvements in nutrition knowledge and dietary variables including

total calorie intake and percentage macronutrient calorie contributions following an individualised nutrition intervention. This offers support to the finding of the current study regarding a link between nutrition knowledge and carbohydrate intake.

However, additional evidence supporting the implementation of nutrition education interventions with the general public is lacking, especially with regard to fibre intake. Furthermore, intervention studies have not provided evidence of follow-up work to investigate whether or not interventions have a lasting positive effect which limits the potential to suggest education interventions as a means of improving health on a large scale, for example, as part of the National Curriculum for schools. It would also be worth investigating the lasting effect of nutrition education; do improvements in nutrition knowledge and diet quality persist in adulthood?

2.7. Conclusion

The significant findings of the current study add to the body of evidence which suggests that nutrition education to improve nutrition knowledge could be used as an intervention to improve food intake. What intervention studies have found, further study, recommendations for intervention

Nutrition knowledge and food intake is a complex issue which is perhaps why there is doubt concerning the results of studies investigating the issue. However, correlations are frequently found and it may be possible to build small pieces of

evidence into a large body supporting a link between nutrition knowledge and food intake. It is hoped that the results of the current study will add to the large body of research and facilitate individual and nationwide decisions regarding nutrition education.

There is still huge scope for research in the field of nutrition knowledge. The relationship with micronutrient intake is something that needs to be established and understanding of the mediatory effect of nutrition knowledge in relation to other determinants of food intake requires further investigation.

Reference List

- Anderson, J. W., Baird, P., Davis Jr., R. H., Ferreri, S., Knudtson, M....Williams, C. L. (2009). Health benefits of dietary fiber. *Nutrition Reviews* 67(4) 188-205 doi:10.1111/j.1753-4887.2009.00189.x
- Bates, B, Lennox, A., Bates, C., Swan, G. (2011). National diet and nutrition survey: headline results from years 1 and 2 (combined) of the rolling programme (2008/2009 - 2009/10). Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/152235/dh_128542.pdf.pdf
- Beydoun, M. A., Powell, L. M. & Wang, Y. (2009). Reduced away-from-home food expenditure and better nutrition knowledge and belief can improve quality of dietary intake among US adults. *Public Health Nutrition* 12(3) 369-81 doi:10.1017/S1368980008002140
- Cancer Research UK (2012). *Cancer incidence for all cancers combined*. Retrieved from <http://www.cancerresearchuk.org/cancer-info/cancerstats/incidence/all-cancers-combined/>
- Dallongeville, J., Marécaux, N., Cottel, D., Bingham, A. & Amouyel, P. (2001). Association between nutrition knowledge and nutritional intake in middle-aged men from Northern France. *Public Health Nutrition* 4(1) 27-33.
- Dennison E, Cole Z, Cooper C. (2005). Diagnosis and epidemiology of osteoporosis. *Current Opinion in Rheumatology*, 17(4), 456-461
- Diabetes UK (2010). Diabetes in the UK 2010: Key statistics on diabetes. Retrieved from http://www.diabetes.org.uk/Documents/Reports/Diabetes_in_the_UK_2010.pdf
- Fahlman, M. M., Dake, J. A., McCaughtry, N. & Martin, J. (2008). A pilot study to examine the effects of a nutrition intervention on nutrition knowledge, behaviors, and efficacy expectations in middle school children. *Journal of School Health* 78(4) 216-22. doi: 10.1111/j.1746-1561.2008.00289.x.
- Fusillo, A. E. & Beloian, A. M. (1977). Consumer nutrition knowledge and self reported food shopping behavior. *American Journal of Public Health* 67(9) 846-850 Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1653717/>

- Gracey, D., Stanley, N., Burke, V., Corti, B. & Beilin, L. J. (1996). Nutritional knowledge, beliefs and behaviours in teenage school students. *Health Education Research* 11(2) 187-204 doi: 10.1093/her/11.2.187
- Hall, M. N., Chavarro, J. E., Lee, I-M., Willet, W. C. & Ma, J. (2008). A 22-year prospective study of fish, n-3 fatty acid intake, and colorectal cancer risk in men. *Cancer Epidemiology Biomarkers and Prevention*, 17(5), 1136-43. doi: 10.1158/1055-9965.EPI-07-2803
- Howard, B. V. & Wylie-Rosett (2002).
A statement for healthcare professionals from the committee on nutrition of the council on nutrition, physical activity, and metabolism of the American Heart Association. *AHA Scientific Statement Sugar and Cardiovascular Disease*, 106, 523-527. doi: 10.1161/01.CIR.0000019552.77778.04
- Hoogenboom BJ, Morris J, Morris C, Schaefer K. (2009). Nutritional knowledge and eating behaviors of female, collegiate swimmers. *North American Journal of Sports Physical Therapy* 4(3) 139-48. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2953338/>
- Jeppersen, J., Schaaf, P., Jones, C., Zhou, M-Y., Ida Chen, Y-D & Reaven, G. M. (1997). Effects of low-fat, high-carbohydrate diets on risk factors for ischemic heart disease in postmenopausal women. *American Journal of Clinical Nutrition*, 65(4), 1027-1033. Retrieved from <http://ajcn.nutrition.org/content/65/4/1027.full.pdf+html>
- Kandiah, J. & Jones, C. (2002). Nutrition knowledge and food choices of elementary school children. *Early Child Development and Care* 172(3) 269-273 doi: 10.1080/03004430212123
- Klohe-Lehman, D. M., Freeland-Graves, J., Anderson, E. R., McDowell, T., Clarke, K. K.,...Milani, T. J. (2006). Nutrition knowledge is associated with greater weight loss in obese and overweight low-income mothers. *Journal of the American Dietetic Association* 106(1) 65-75 doi:10.1016/j.jada.2005.09.047
- Lee, S., Shafe, A. C. E. & Cowie, M. R. (2011). UK stroke incidence, mortality and cardiovascular risk management 1999-2008: time-trend analysis from the General Practice Research Database [Press release]. *BMJ Open*, 1(2). doi:10.1136/bmjopen-2011-000269
- Lindström, J., Peltonen, M., Eriksson, J. G., Louheranta, A., Fogelholm, M., Uusitupa, M. & Tuomilehto, J. (2006). High-fibre, low-fat diet predicts long-term weight loss and decreased type 2 diabetes risk: the Finnish Diabetes Prevention Study. *Diabetologia*,

(49)5, 912-920. doi 10.1007/s00125-006-0198-3

- Marshall, J. A., Hamman, R. F. & Baxter, J. (1991). High-fat, low-carbohydrate diet and the etiology of non-insulin-dependent diabetes mellitus: the San Luis Valley diabetes study. *American Journal of Epidemiology*, 134(6), 590-603. Retrieved from <http://aje.oxfordjournals.org/content/134/6/590.full.pdf#page=1&view=FitH>
- Nichols, M., Townsend, N., Scarborough, P. & Rayne, M. (2012). European cardiovascular disease statistics: 2012 edition. Retrieved from <http://www.escardio.org/about/Documents/EU-cardiovascular-disease-statistics-2012.pdf>
- Paddon-Jones, D., Short, K. R., Campbell, W. W., Volpi, E. & Wolfe, R. R. (2008). Role of dietary protein in the sarcopenia of aging. *American Journal of Clinical Nutrition*, 87(5), 1562S-1566S. Retrieved from <http://www.ajcn.org.voyager.chester.ac.uk/content/87/5/1562S.full?sid=b443c64f-b7da-4900-9ba2-3a1caf4bb661>
- Parmenter, K. & Wardle, J. (1999). Development of a general nutrition knowledge questionnaire for adults. *Journal of Clinical Nutrition*, 53, 298-308. Retrieved from <http://www.ucl.ac.uk/hbrc/diet/140.pdf>
- Pieniak, Z., Verbeke, W. & Scholderer J. (2010). Health-related beliefs and consumer knowledge as determinants of fish consumption. *Journal of Human Nutrition and Dietetics* 23(5) 480-488. doi: 10.1111/j.1365-277X.2010.01045.x.
- Perron, M., & Endres, J. (1985). Knowledge, attitudes, and dietary practices of female athletes. *Journal of the American Dietetic Association* 85(5) 573-6.
- Popkin, B. M. (2006). Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. *American Journal of Clinical Nutrition*, 2 289-298 Retrieved from <http://ajcn.nutrition.org/content/84/2/289.full>
- Powers, A. R., Struempfer, B. J., Guarino, A. & Parmer, S. M. (2005). Effects of a nutrition education program on the dietary behavior and nutrition knowledge of second-grade and third-grade students. *Journal of School Health* 75(4) 129-33. Retrieved from http://www.myteachersite.net/Effects_of_Nutr_Educ_article.pdf
- Rash, C. L., Malinauskas, B. M., Duffrin, M. W., Barber-Heidal, K., Overton, R. F. (2008). Nutrition-related knowledge, attitude, and dietary intake of college track athletes. *Sport Journal* 11(1) 1-8. Retrieved from <http://zh8wk8vq8w.search.serialssolutions.com/?genre=article&issn=15439518&title=Sport+Journal&volume=11&issue=1&date=20080101&atitle=Nutrition->

[related+knowledge%2c+attitude%2c+and+dietary+intake+of+college+track+athletes.&spage=48&pages=48-54&sid=EBSCO:SPORTDiscus+with+Full+Text&aulast=Rash%2c+Courtney+L.](#)

- Sakamaki, R., Toyama, K., Amamoto, R., Liu, C. & Shinfuku, N. (2005). Nutritional knowledge, food habits and health attitude of Chinese university students - a cross-sectional study. *Nutrition Journal*, 4(4) doi: 10.1186/1475-2891-4-4
- Scarborough P, Wickramasinghe K, Bhatnagar P, Rayner M (2011). *Trends in coronary heart disease 1961-2011*. British Heart Foundation: London. Retrieved from <http://www.bhf.org.uk/plugins/PublicationsSearchResults/DownloadFile.aspx?docid=2cc83960-2173-4fd4-a46c-0fb43c22baa4&version=-1&title=Trends+in+coronary+heart+disease%2C+1961-2011&resource=M129>
- Shah, P., Misra, A., Gupta, N., Hazra, D. K., Gupta, R.,...Goel, K. (2010). Improvement in nutrition-related knowledge and behaviour of urban Asian Indian school children: findings from the 'Medical education for children/Adolescents for Realistic prevention of obesity and diabetes and for healthy aGeing' (MARG) intervention study. *British Journal of Nutrition* 104(3):427-36. doi: 10.1017/S0007114510000681
- Sperrin, M., Marshall, A. D., Higgins, V., Buchan, I. E. & Renehan, A. G. (2013). Slowing down of adult body mass index trend increases in England: a latent class analysis of cross-sectional surveys (1992-2010). *International Journal of Obesity* doi:10.1038/ijo.2013.161
- Steele & O'Sullivan (2011). Executive summary: adult dental health survey 2009. London: The Health and Social Care Information Centre. Retrieved from <https://catalogue.ic.nhs.uk/publications/primary-care/dentistry/adul-dent-heal-surv-summ-rep-them-seri-2009/adul-dent-heal-surv-summ-them-exec-2009-rep2.pdf>
- Valliant, M.W., Emplaincourt, H. P., Wenzel, R. K. & Garner, B. H. (2012). Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients* 4(6):506-16. doi: 10.3390/nu4060506
- Walsh, M., Cartwright, L., Corish, C., Sugrue, S. & Wood-Martin, R. (2011). The body composition, nutritional knowledge, attitudes, behaviours and future education needs of senior schoolboy rugby players in Ireland. *International Journal of Sport Nutrition and Exercise Metabolism* 21, 365-376

- Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet* 378(9793), 815-825. doi:10.1016/S0140-6736(11)60814-3
- Wardle, J., Parmenter, K. & Waller, J. (2000). Nutrition knowledge and food intake. *Appetite* 34(3) 269-275 doi:10.1006/appe.2000.0314
- World Health Organisation (2003). Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation (WHO Technical Report Series 916). Retrieved from http://whqlibdoc.who.int/trs/WHO_TRS_916.pdf
- World Health Organisation. (2005). The impact of chronic disease in the United Kingdom. Retrieved from http://www.who.int/chp/chronic_disease_report/media/uk.pdf
- World Health Organisation. (2013). NCD mortality and morbidity. Retrieved from http://www.who.int/gho/ncd/mortality_morbidity/en/index.html

Appendix 2

General nutrition knowledge questionnaire for adults
K Parmenter and J Wardle

Fahlman, Dake, McCaughy and Martin	2008	407 middle school students	Intervention – control and treatment	33 questions about food students ate ‘yesterday’	20 questions based on content of education intervention	Knowledge and behaviour improved post-intervention in treatment. Knowledge and fruit and vegetable consumption increased post-intervention in treatment compared to control.
Kandiah and Jones	2002	187 primary school students	Intervention – control and treatment	3 day food record	25 multiple choice questions	NK increased in treatment not in control. Intake of grains, milks, fruit and veg. increased in treatment not in control.
Powers et al.	2005	1100 2 nd and 3 rd grade students	Intervention – control and treatment	24 behaviour questions with ‘yes/no’ answers	16 questions based on nutrition related problems associated with children	Treatment group had greater behaviour and knowledge improvements than control.
Walsh et al.	2011	203 rugby players aged 16-18	Cross-section	Questions investigating dietary behaviours	16 sports nutrition questions	Good knowledge not necessarily related to good behaviours. Good hydration practices related to good nutrition knowledge.
Gracey et al.	1996	391 year 11 students	Cross-section	16 questions to determine usual intake of fatty foods, water and soft drinks	8 multiple choice questions predominantly fat and fibre	Knowledge predicted variety of foods consumed. Knowledge not correlated to fat intake.
Valliant et al.	2012	11 volleyball players aged 19-22	Intervention	3 day food records	Reilly and Maughan sports nutrition questionnaire	Improvements in knowledge as well as improvements in diet
Rash et al.	2008	113 college track athletes	Cross-section	Food frequency questionnaire to assess 12 preceding months	Questionnaire covering carbohydrates, protein, vitamins and minerals – 2-5 true/false statements per subject area.	Weak correlation for knowledge and diet quality ($r = 0.001$, $p \leq 0.05$).

Appendix 2

General nutrition knowledge questionnaire for adults
K Parmenter and J Wardle

Dallongeville et al.	2001	361 French men aged 45-64	Cross-section	3 day food record	10 questions concerning composition of food and nutrition practices related to CHD risk.	Intake differed at different levels of knowledge. Most notably, fat intake was higher in those with lower knowledge.
Wardle, Parmenter and Waller	2000	1039 British adults aged 51 ± 5 years	Cross-section	Food frequency questionnaire – modified version of Dietary Instrument of Nutrition Education	Nutrition Knowledge Questionnaire (Parmenter and Wardle, 1999)	Knowledge correlated with vegetable intake ($r = 0.36$), fruit intake ($r = 0.23$) and fat intake ($r = 0.21$, $p \leq 0.05$)
Beydoun, Powell and Wang	2009	4252 US adults aged between 20 and 65	Cross-section	One or two 24 hour food recall – diet quality estimated using Healthy Eating Index	11 Likert scale questions - mainly measured beliefs and attitudes	Improved knowledge correlated with improved diet quality.

Pieniak, Verbeke and Scholderer	2010	4786 Europeans mean age 43 ± 12.6	Cross-section – knowledge and fish consumption	Self-reported fish consumption ranging from ‘never’ to ‘daily’	4 true/false statements relating to fish consumption	Knowledge had a positive but weak association with fish consumption frequency
---------------------------------	------	-----------------------------------	--	--	--	---

Caballero et al.	2006	300 adults mean age 42, 95% Native American	Cross-section	Intake not assessed, instead purchasing behaviours, preparation and consumption	9 multiple choice questions, 8 questions on label reading knowledge	Confidence in carrying out healthy practices regarding purchasing behaviours, preparation and consumption increased as knowledge increased.
------------------	------	---	---------------	---	---	---

Shah et al.	2010	3128 children 8-18	Intervention	Dietary behaviours – no quantitative data	Prepared by National Foundation for Diabetes and Cholesterol Disorders – health, nutrition, diseases, physical activity and healthy cooking practices; 15-45 questions for each theme	Knowledge-behaviour ($r = 0.687$, $p \leq 0.05$). Knowledge and behaviours improved post intervention.
-------------	------	--------------------	--------------	---	---	---

Klohe-Lehman et al.	2006	141 overweight women mean age = 28	Intervention – effects of knowledge on weight loss	No assessment	17 multiple choice questions, 8 true/false statements covering weight loss, heart disease, prenatal nutrition, child nutrition, Food Guide Pyramid, sources and functions of macro and micronutrients	Women who lost weight had higher pre and post-test knowledge than non-responders. Correlation between pounds lost and macronutrient knowledge (r = 0.25, p=≤0.05). Both responders and non-responders gained knowledge.
Fusillo and Beloian	1977	1664 US adults	Cross-section – knowledge and shopping behaviour	Intake not assessed, instead shopping behaviours assessed with 7 yes/no questions	5 areas of knowledge questioning including nutrient composition, body’s use of nutrients, macro- and micronutrients	A positive association between knowledge and careful shopping

APPENDIX 2

Questionnaire taken from Parmenter, K., & Wardle, J. (1999). Development of a general nutrition knowledge questionnaire for adults. *European Journal of Clinical Nutrition*, 53, 298-308

Appendix 3

Instructions:

- Complete the on-line questionnaire which is available here:
<https://www.surveymonkey.com/s/TP3JZMW>
- Download the app. The required app. is the Fat Secret calorie counter which can be downloaded for free. PLEASE COMPLETE THE QUESTIONNAIRE BEFORE DOWNLOADING AND USING THE APP.
- The app. is basically a food diary into which you enter the food you eat.
- Begin using the app. to record your food intake on Sunday 2nd September
- Use the app. to record everything you eat and drink in a day and repeat this three times in the week beginning Sunday 2nd September. One of the three days must be a weekend day. Make three more diary entries in the week beginning Sunday 23rd September.
- You can choose any 3 days within the weeks (as long as one is a weekend) or follow my suggestion:

September 2012						
Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
1	² DIARY ENTRY	³ DIARY ENTRY	⁴ DIARY ENTRY	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	²³ DIARY ENTRY	²⁴ DIARY ENTRY	²⁵ DIARY ENTRY	26	27	28
29	30					

- Send each day's diary entry to the e-mail address @chester.ac.uk. This can be done using the export function of the app. (select 'detailed report' and 'pdf format'). **Please also add your participant number to the e-mail.**

Tips for using the Fat Secret calorie counter:

- **Try to remember everything you ate.** For example butter in a sandwich, cooking oil, sauces/dressings etc.

- **Try to be as specific as possible.** For example, 'white bread' instead of just 'bread' or 'semi-skimmed milk' instead of just 'milk'.
- **Remember to include the portion size**, whether it's the amount (e.g. 1 slice of bread), the weight (e.g. 50 grams of cheese) or the volume (e.g. 30 ml of milk).
- **Try to make sure that what you enter into the food diary actually matches what you ate.** When you enter a food, the app. uses a database to generate nutritional information which may not match exactly what you ate. For example if you entered 'cheese omelette' into the diary, the cheese omelette in the database may have been made using two eggs and edam cheese whereas yours was made with three eggs and cheddar cheese. Another example could be chilli con carne; the database food may contain kidney beans and tomatoes whereas yours contained neither. In these situations it may be best to enter the ingredients individually, i.e. three eggs, 100 grams of cheddar cheese; 50 grams beef mince, 1 tbsp tomato puree etc.
- If the food you are searching for is not in the database try to pick the one that is most closely matched.

SEVEN WAYS TO SIZE UP YOUR SERVINGS

Measure food portions so you know exactly how much food you're eating. When a food scale or measuring cups aren't handy, you can still estimate your portions.

Remember:

3 ounces of meat is about the size and thickness of a deck of playing cards or an audiotape cassette.

3 oz. = 80 g



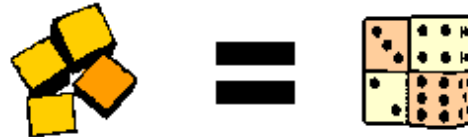
A medium apple or peach is about the size of a tennis ball.

1 = approx. 100 g



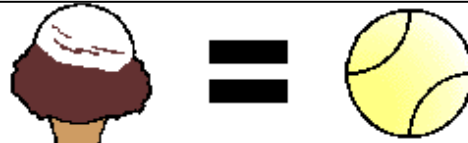
1 ounce of cheese is about the size of 4 stacked dice.

1 oz. = 30 g



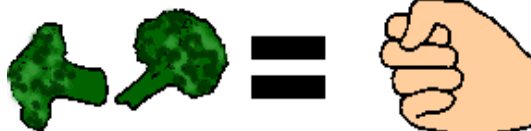
1/2 cup of ice cream is about the size of a racquetball or tennis ball.

1 scoop = 75 g



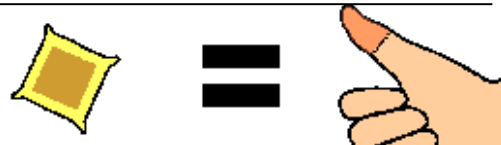
1 cup of mashed potatoes or broccoli is about the size of your fist.

1 serving = approx. 100 g



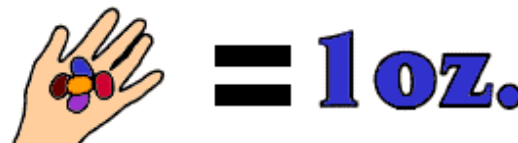
1 teaspoon of butter or peanut butter is about the size of the tip of your thumb.

1 tsp = 5 g



1 ounce of nuts or small candies equals one handful.

1 oz. = 30 g = approx. 5 nuts





Participant information sheet

Effects of a smartphone app. on nutrient intake in adults.

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

The aim of this study is to see whether the simple act of recording what we eat on a daily basis can have an effect on the food we choose to eat in the future.

Why have I been chosen?

You have been chosen because you are an adult. There are other criteria you must meet before entering into the study but these will be assessed once you have agreed to take part.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect you in any way.

What will happen to me if I take part?

If you meet all of the necessary criteria you will firstly be asked to complete an on-line questionnaire, which should take between 25 and 30 minutes to complete. You will then be asked to record your daily food intake for three days in a row. Following this you will be asked to wait 17 days before recording another 3 days of daily food intake. Finally, 24 days after completing the on-line questionnaire, you will be asked to complete another questionnaire to end the study.

What are the possible disadvantages and risks of taking part?

There are no disadvantages or risks foreseen in taking part in this study.

What are the possible benefits of taking part?

Keeping a food diary may make you aware of the nutritional value of your food and highlight areas in which your diet could improve. Completing a nutritional knowledge questionnaire may identify areas in which your knowledge could be improved. This information will be feedback to you and you may choose to improve your knowledge which may in turn improve your diet health. At the end of the trial, you will be provided with information on healthy eating and ways in which you can improve your health.

Your participation in this study may lead to the development of new and innovative ways to promote healthy eating in the wider society.

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Professor Sarah Andrew, Dean of the Faculty of Applied Sciences, University of Chester, Parkgate Road, Chester, CH1 4BJ, 01244 513055.

Will my taking part in the study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information.

What will happen to the results of the research study?

The results will be written up into a dissertation for my final project of my MSc. Individuals who participate will not be identified in any subsequent report or publication.

Who is organising the research?

The research is conducted as part of an MSc in Exercise and Nutrition Science within the Department of Clinical Sciences at the University of Chester. The study is organised with supervision from the department by Josh Stroud, an MSc student.

Who may I contact for further information?

If you would like more information about the research before you decide whether or not you would be willing to take part, please e-mail:

@chester.ac.uk

Thank you for your interest in this research.



Title of Project: Effects of a smartphone app. on nutrient intake in adults

Name of Researcher: Josh Stroud

Please initial box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without my legal rights being affected.
3. I agree to take part in the above study.

☐☐☐

Name of Participant

Date

Signature

Researcher

Date

Signature

1 for participant; 1 for researcher

Appendix 6

1. Are you in the 18 – 64 age range?

(a) Yes

(b) No

2. Are you currently attempting planned and deliberate weight loss? For example, a weight loss diet and/or exercise regime.

(a) Yes

Please specify:

(b) No

3. Do you have any health or nutrition related qualifications?

(a) Yes

Please specify:

.....

(b) No

4. Are you currently using any method to record your daily food intake? For example writing a food diary, using a smartphone app., photographing meals, etc.

(a) Yes

Please specify:

(b) No

Potential participants will be given this questionnaire once they have expressed an interest in taking part.

Answering ‘no’ to Question 1, ‘yes’ to Question 2 – 5 or (c) to Question 6 will exclude participants from entering into the study.

5. Are you currently following a particular diet plan?

(a) Yes

Please specify:

(b) No

6. What is your current domiciliary status?

(a) Living alone

(b) Living with partner/spouse

(c) Living with parents

(d) Living with friends

(e) Other – please specify

.....



Participants wanted

Are you aged 18 – 64? Do you own a smartphone (e.g. iPhone, Blackberry, HTC, Samsung Galaxy, etc.)? Are you free to eat whatever you like whenever you like?



If you answer **‘yes’** to all of the above then why not take part in an MSc student’s scientific research and help to further the cause of healthy eating?

There will be no cost to you and no need to attend any research sessions; the research can be integrated into your daily life.

You won’t need to change your eating habits either, but you may just find that after taking part your diet will become healthier!

For further info. send an e-mail quoting **‘yes’** to **@chester.ac.uk**